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Full Length Research Paper

Evaluation of Calcium and Phosphorus Release Pattern and Composition of Bulk-blended NPK 20:10:10 Fertilizer formulated using Ogun Phosphate rock as the P source.

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Abstract

Experiment was conducted in the laboratory at the University of Agriculture, Abeokuta, Southwest Nigeria to evaluate the composition and nutrient release pattern of bulk-blended NPK 20:10:10 fertilizer formulated using Ogun phosphate rock as the P source. The grade, stability and incubation studies on the Gateway fertilizer compared to a Standard fertilizer were carried out in the laboratory. The release pattern of phosphorus in the bulk-blended product was determined by an incubation study in the laboratory. 250g of soil was mixed with 50g fertilizer, moistened with distilled water to field capacity, and incubated in a sealed polythene bag for a period of four months. The soil was thoroughly mixed with the fertilizers (Standard and Gateway) and sampled every two weeks for analysis of available P, exchangeable Ca^{2+} and pH. The two fertilizers were compared using two soil series namely; Agege (Arenic tropudalt) and Iwo (Kandic palenstalf). . Laboratory analysis showed that the grade of the Gateway fertilizer was 10:5:7 and the Standard 12:9:6. Stability study after four months revealed that P content decreased by 34.0 and 41.1 %, respectively in Gateway and the Standard fertilizers. Incubation with soil for 14 weeks led to 48.6 and 68.5 % P decrease, respectively in Gateway and Standard fertilizer. However, Ca content increased with incubation while changes in pH were inconsistent. It is important to note that highest P values were recorded for the two fertilizers under Agege soil series than Iwo series. It was concluded therefore that Gateway fertilizer will benefit acid soils but the nutrient content should be improved upon to meet the stated analysis on the bag.

Key words: Phosphate rock, available P, bulk blending, incubation, stability.

Introduction

Phosphorus is an essential element for all living organisms. However, most tropical soils are inherently low in phosphorus (P) due to nutrient mining, among other factors. Therefore there is need for P inputs to maintain crop production in these soils (Keane, 2001; Sanchez, 2004; Amberger, 2006; Syers *et al.,* 2008). Also with the need to increase food production to feed the increasing population in tropical countries, P fertilizers use has become very important in this part of the world.

The high cost and non-availability of manufactured P fertilizers is a major constraint to plant P nutrition in most developing countries. The high cost of P fertilizers (production and transportation) has led to its low input by most farmers and thus a decline in crop yields. The good news however, is that phosphate rock (PR) is found in many African countries. Mokwunye (2004) observed that applying phosphate rock may be the best alternative to the manufactured water- soluble P fertilizers because West Africa has abundant supplies of phosphate rock. The ability of some indigenous PRs to supply phosphorus for crop production has been well documented (Rajan *et al.,* 1996; Johnston and Syers, 1998; Mokwunye, 2004).

Nigeria is also blessed with many PR deposits with that of Ogun phosphate rock (OPR) and Sokoto phosphate rock (SPR) being the well known of these deposits. The analysis of OPR revealed that it contains 31.38% P_2O_5 and 31.68% CaO (Jones and Dempster, 1969). Several authors have identified the potentials of OPR as P source for agricultural production purposes and found that it is feasible (Akintokun *et al*., 2003; Shokalu, 2003; Akande, 2005, Olla *et al.*, 2010). Moreover, the potential of P mineral fertilizers to improve the productivity of many soils had been researched in Nigeria (Adepetu, 1983; Adetunji, 1994a, 1994b, 1995, 1997). However, only recently has attempt been made to use the OPR in compounding NPK fertilizer in bulk blending. This study was therefore conducted to determine the analyzed grade, stability and evaluate the nutrient release pattern of phosphorus in the bulk blended NPK 20: 10:10 formulated using OPR as the P source in the laboratory.

Materials and Methods

Location

The experiment was carried out in the Department of Soil Science and Land Management laboratory, Federal University of Agriculture, Abeokuta, Nigeria. The University is located between Latitude $7^o.14^1$N and Longitude $3^o.26^1$E. The area lies in the derived savanna ecological zone of Ogun State, Southwest of Nigeria. The rainfall, which is bimodal, commences in late March to early April and ends in late October to early November with a short dry spell in August. The mean annual rainfall is about 1077 mm with the maximum in July and September. The mean monthly temperature varies between 28^oC and 32^oC.

Fertilizer Analysis

Two fertilizers were used for this study. The NPK 20:10:10 (standard) that is, the one already in the market was formulated by Golden fertilizer company Nigeria while the Gateway fertilizer (used OPR as the P source) was formulated by Gateway fertilizer company, Ogun State. The two fertilizers were analyzed for % total N, % P_2O_5 and % K_2O. Total N was determined by the regular macro-Kjeldahl method (IITA, 1979). Available P was determined colorimetrically from spectrophotometer using ammonium molybdate method (Bray and Kurtz, 1945). Exchangeable K was determined in NH_4OAc extract using the flame photometer (IITA, 1979).

Stability test was carried out on both the Standard fertilizer and Gateway fertilizers to evaluate the storability of the fertilizer. The fertilizer was sampled monthly for the analysis of available P (ammonium molybdate method) and pH only.

The release pattern of phosphorus in the bulk-blended product was determined by an incubation study in the laboratory. 250g of soil (passed through 2mm sieve) was mixed with 50g fertilizer, moistened with distilled water to field capacity, and incubated in a sealed polythene bag for a period of four months. The soil was thoroughly mixed with the fertilizers (Standard and Gateway) and sampled every two weeks for analysis of available P, exchangeable Ca^{2+} and pH. The two fertilizers were compared using two soil series namely; Agege and Iwo. Taxonomically, Agege series belong to Arenic tropudalt while Iwo series belong to Kandic palenstalf according to USDA classification (Aiboni, 2001a and b).

Soil Analysis

Soil pH (1:2) in water was determined using glass electrode pH meter. Available P was measured using Bray-1 P method and P content determined colorimetrically from spectrophotometer using ammonium molybdate method (Bray and Kurtz, 1945) while exchangeable Ca^{2+} was determined in NH_4OAc extract using atomic absorption spectrophotometer (AAS) (IITA, 1979).

Data Analysis

All the data collected were subjected to analysis of variance, using SAS statistical package (1988), and treatment means separated using Duncan Multiple range Test (DMRT) at P= 0.05.

Results and Discussion

The characteristics of the two soils used for the study are presented in Table 1. The table indicated that the soils are generally low to medium in total nitrogen, organic carbon and available P. The soils are slightly acidic and belong to textural class sand.

Chemical composition of the fertilizer samples

The analytical values of the Gateway and the Standard fertilizer products are given in Table 2. The result showed that the analyzed grades for the Gateway fertilizer are approximately 10: 5: 7 and 12: 9: 16 for the Standard fertilizer, instead of the specified grade of 20:10: 10 for both fertilizers. Thus, Gateway and Standard fertilizers had nutrient contents lower than stipulated. This may be due to poor or ineffective quality control in this company. A similar observation was made by IFDC (1995) that nutrient deficiencies in blends seem to be the result of poor process control and /or poorly size – matched raw materials. Nigeria was ranked higher than Benin republic and Ghana in terms of the percentage of nutrient- deficient fertilizers (IFDC, 1995).

Table 1: Some chemical and physical properties of the soils used

	Soil property	Iwo	Agege
	pH (H_2O)	6.04	6.70
	Org C (%)	7.20	13.40
	Total N (g kg^{-1})	0.90	1.40
	Av.P Bray1 (mg kg^{-1})	6.00	13.72
Exchangeable	Ca (cmol kg^{-1})	2.08	4.13

,,	Mg (cmol kg^{-1})	0.66	1.54
,,	K (cmol kg^{-1})	0.37	0.13
,,	Na (cmol kg^{-1})	0.26	0.25
	CEC (cmol kg^{-1})	3.37	6.05
	Sand	96.0	96.2
	Silt	0.4	0.3
	Clay	3.6	3.5
	Textural class	Sand	Sand

Table 2: Nutrient contents of the NPK 20:10:10 fertilizer

	Nutrient content (%)		
Fertilizer	N	P_2O_5	K_2O
Gateway	10	4.58	7.20
Standard	12	9.16	15.60

Stability study

Changes in pH and available P contents of the two fertilizers monitored over a period of four months are presented in Figures 1 and 2 respectively. Changes in fertilizer pH were significant only in Gateway fertilizer. However, the change in pH did not give any definite trend in both fertilizers. Changes in available P values were significant in both fertilizers. The available P reduced with storage period. The trend was more consistent in the Standard fertilizer. After four months, the P content had decreased by 34% in Gateway fertilizer and 41.13% in Standard fertilizer in both Agege and Iwo soil series. Consequently, the amounts of P that these fertilizers can supply will also decrease as the period of storage increases.

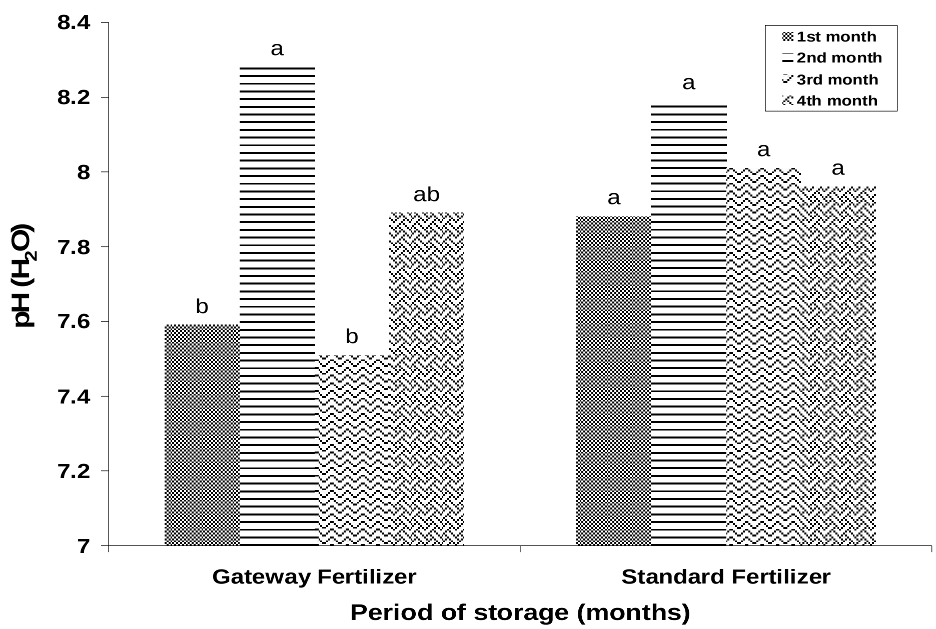

Figure 1: Changes in pH of the inorganic fertilizers over a storage period of four months.

†Means within a fertilizer treatment followed by the same letters are not significantly different at 5% level of probability using Duncan's Multiple Range Test.

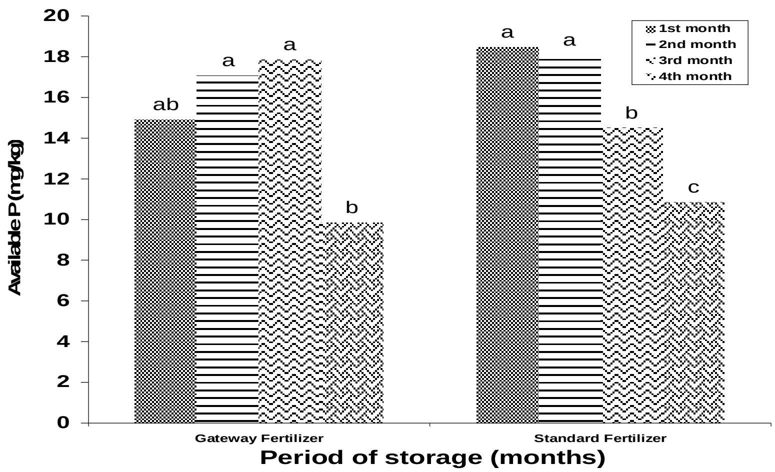

Figure 2: Changes in phosphorus contents of the inorganic fertilizers over a storage period of four months.
†Means within a fertilizer treatment followed by the same letters are not significantly different at 5% level of probability using Duncan's Multiple Range Test.

Incubation study

The changes in pH, available P and exchangeable Ca during incubation of the fertilizer materials with two soil samples over a period of 14 weeks in the laboratory are presented in Figures 3, 4 and 5 respectively. Initially changes in fertilizer pH were significant in both fertilizers, however, as the incubation time progressed both fertilizers were not significantly different in their pH values. Changes in available P values were significant in both fertilizers. The available P values decreased with incubation period in both fertilizers in the two soils used for the experiment.

After 14 weeks of incubation in the laboratory, P content had reduced by about 9.62 mg kg^{-1} in Gateway and 15.19 mg kg^{-1} in Standard fertilizer in Iwo soil series while a decrease of about 22.23 mg kg^{-1} in Gateway fertilizer and 14.02 mg kg^{-1} in Standard was observed in Agege soil series. In contrast to the trend observed in available P, the amounts of exchangeable Ca present increased as the weeks of incubation increased except in the Standard fertilizer with Agege soil series. The changes observed in the Ca concentration were significant in both fertilizers except in Standard under Iwo soil series. It is important however, to note that highest P values were recorded for the two fertilizers under Agege soil series than Iwo series. This might be unconnected with the low pH, low exchangeable Ca^{2+} and available P of the soil (Table 1). Low pH, low exchangeable Ca^{2+} and low P concentration are common characteristics of many tropical, weathered soils. Also acid soils are more conducive to PR dissolution than Ca^{2+} rich alkaline soils (Hammond *et al.,* 1986b). The reduction in available P with the length of incubation might result from the increase in exchangeable Ca^{2+} in both soils where GF was applied. The decrease in available P is consistent with previous observations that a lower concentration of Ca^{2+} favoured the dissolution and the release of P from the phosphate rock (Rajan *et al.*, 1996). This may explain the higher level of available P observed in soils where SF was applied compared with the GF. The reason might be because most phosphate rocks are known to contain certain percentage of Ca^{2+} in their apatite of which OPR (31.86 %) is not an exception. The increase in the amount of exchangeable Ca^{2+} with length of incubation is in agreement with earlier observation made by Akande (2005).

Summary and Conclusion

The use of phosphate rocks to replace the expensive water- soluble sources of P fertilizer is gaining ground every day. However, the use of OPR in compounding NPK fertilizer in bulk blending has not received any attention in research. This study was conducted therefore, to investigate the blended product for its analyzed grade, stability and the nutrient release pattern of phosphorus in the bulk blended NPK 20: 10:10 formulated using OPR as the P source in the laboratory.

From the findings in this study, the following observations and conclusions could the drawn: The analytical values of Gateway fertilizer showed that it was below the specified grade of NPK 20: 10: 10. Phosphorus content of the Gateway fertilizer reduced with time of storage resulting in a reduction in the nutrient (P) it can supply to plants over time. The pH and Ca content of the soil increased as the P content decreased during the incubation period of the bulk- blended product

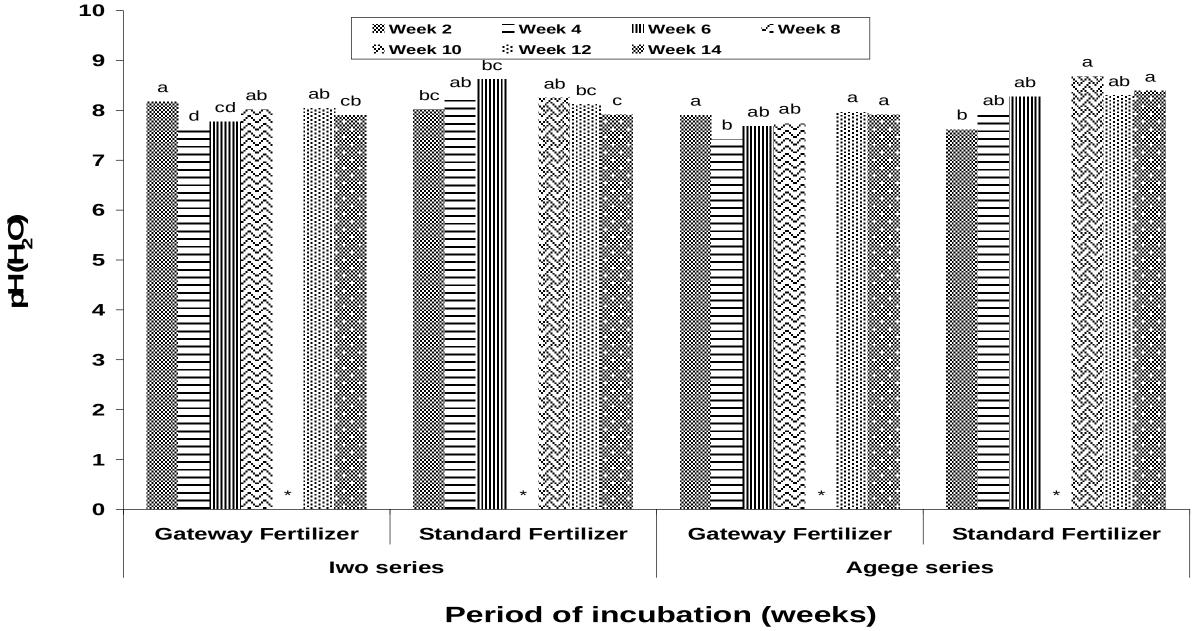

Figure 3: Changes in pH of the inorganic fertilizers after fourteen weeks of incubation.
†Means within a fertilizer treatment followed by the same letters are not significantly different at 5% level of probability using Duncan's Multiple Range Test.
** Values not determined.*

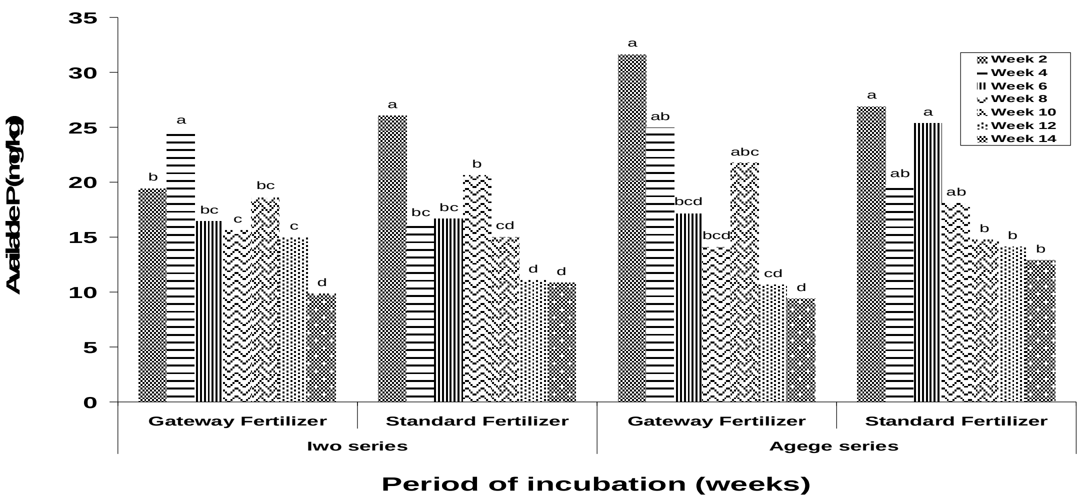

Figure 4: Changes in available phosphorus of the inorganic fertilizers after fourteen weeks of incubation.
†Means within a fertilizer treatment followed by the same letters are not significantly different at 5% level of probability using Duncan's Multiple Range Test.

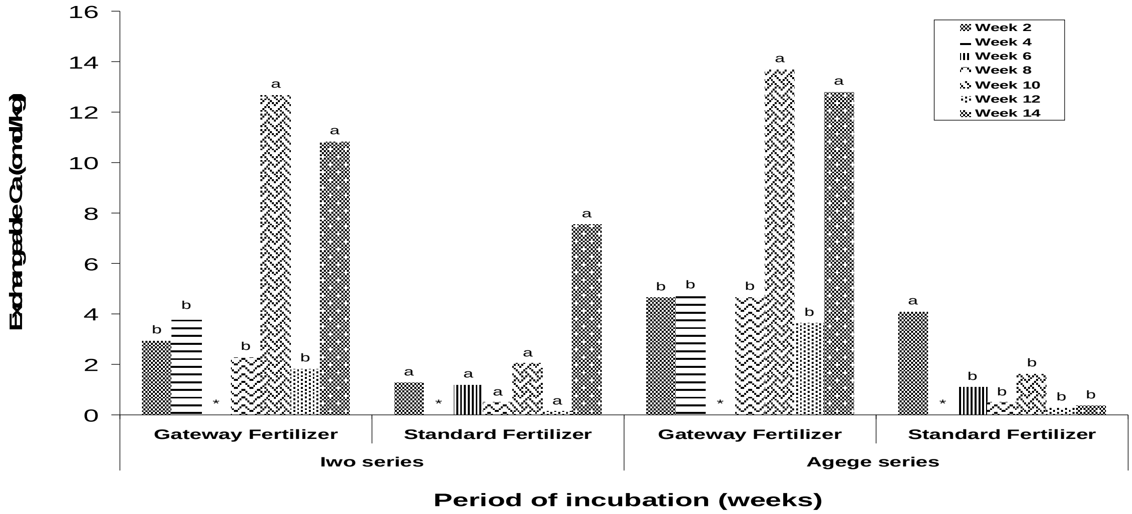

Figure 5: Changes in exchangeable Ca contents of the inorganic fertilizers after fourteen weeks of incubation.
†Means within a fertilizer treatment followed by the same letters are not significantly different at 5% level of probability using Duncan's Multiple Range Test.
** Values not determined.*

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